

Cassini Titan Flyby Environment Thermal Acceptability Evaluation

Abstract

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The Cassini spacecraft will fly by Saturn's largest moon, Titan, 45 times over a period of 44 months during its science tour. Titan's diameter is approx. 40% that of Earth's and is the second largest moon in the Solar System. Titan's atmosphere is planet-like and is denser than Earth's atmosphere. Twenty-four of the flybys will have sufficiently low closest approach target altitudes in Titan's upper atmosphere to be of thermal concern.

Given this thermal concern and current operational plans with respect to Titan flybys, the Thermal/Devices Team on the Cassini Project in Mission Operations at the Jet Propulsion Laboratory has performed a spacecraft environmental thermal acceptability evaluation with respect to the Titan flybys.

The aerodynamic, direct solar, albedo, and planetary infrared environmental heat loads associated with a flyby have all been taken into account. The dominant and capability limiting heat load is the aerodynamic heating encountered in the upper atmosphere at the lower target altitudes. Its magnitude alone is sufficient to result in heat loads comparable to absorbed direct solar loads in the inner solar system. This is a significant concern for the infrared optical science instruments that must avoid even relatively small direct solar heat loads at Saturn.

Candidate operational flyby scenarios were evaluated where the spacecraft performs science activities requiring certain attitude and power profiles. Fault scenarios were also analyzed where System Fault Protection performs a "Safing" procedure. The "Safing" reconfigures the power and attitude profiles for spacecraft protection and for communication with Earth. There are two Safing scenarios of interest; 1) power and attitude profiles are reconfigured prior to entering Titan's atmosphere, and 2) Safing occurs when the spacecraft is in the atmosphere, or close to it, and power and attitude reconfiguration essentially occur in the atmosphere.

The power transients caused by environmentally induced temperature transients in the Radioisotope Thermoelectric Generators that provide electrical power for Cassini were also evaluated in this thermal acceptability evaluation.

The evaluation is based on the documented Project policies and requirements, mission planning, trajectories, parameter magnitudes, statistical uncertainties, attitude scenarios, and power profiles. Thermal engineers interfaced with Mission Planning, Navigation, and Attitude Control engineers in a systematic way to insure policy and requirement compliance and information accuracy. An end-to-end evaluation was performed that included software selection and use, model visual display techniques, environmental heat

load generation, thermal model predict generation, evaluation of results, reporting, analysis automation and capability retention.

The paper will focus on both the technical analyses performed and the System's level approach taken by the thermal engineers. It will also include lessons learned and recommendations for solving analogous problems and for skills retention in an operations environment.